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INVESTIGATION OF THE EQUATORIAL ANOMALY OF THE IONOSPHERE IN THE EAST ASIATIC ZONE OF THE PACIFIC OCEAN

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SUMMARY

The investigation of the ionosphere in the Pacific Ocean region was carried out by vertical sounding from a ship. The results obtained are discussed with regard to the positions of the F2-layer maximum, the course of f_0F2, as related to the various cycles of solar activity and seasons.

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The investigation of the ionosphere by means of vertical sounding from a probe located on board of a ship took place from May to August 1962 in the region of the Pacific Ocean. The ship's coordinates varied in the 140 -204°E longitude and 18°S — 40°N latitude intervals. The geomagnetic anomaly was studied on the basis of the material collected.

The investigation of the anomaly in the latitude course of critical frequencies f_0F2 for the northern hemisphere in the years 1953-1954 of solar activity minimum has shown that f_0F2 maximum appears in the morning in the equatorial region of magnetic inclination and shifts northward. The maximum reaches its inclination maximum at 1400—1600 hours LT; then it returns back, and at 2100 hours maximum takes place again at the equator. At midnight the magnetic anomaly disappears.

During the period of solar activity maximum, in 1957-1959 the investigations of the anomaly were conducted on the basis of a broader material, accrued during the IGY Period [2, 3]. The character of latitude dependence was found to be somewhat different for the three longitude zones— the African, American and East-Asiatic. At the same time the anomaly effect attains its optimum development at 20.00—00.00 hours, and is maintained till 0200 hours, and, at times up to sunrise. In the morning hours the anomaly is feebly expressed (0800 —1000 h) and only one maximum is present at the geomagnetic equator [3].

* [ISSLEDOVANIYE EKVATORIAL'NOY ANOMALII IONOSFERY V VOSTOCHNO AZIATSKOY ZONE TIKHOGO OKEANA]

In the years of solar activity maximum the anomaly develops three hours later than in the years of s.a.minimum, and ends correspondingly later.

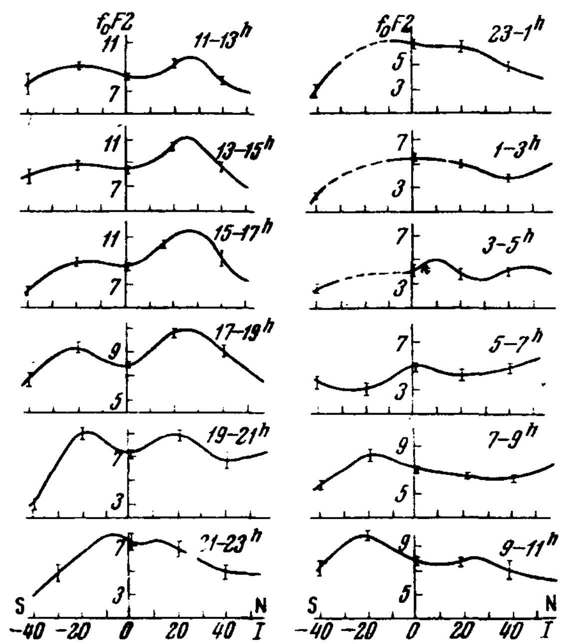

Fig.1

The question of the nature of the geomagnetic anomaly of f_0F2, (I) was investigated in a series of works [4–7]. Appleton ventured a hypothesis, according to which the decrease of f_0F2 near the equator may be linked with a significant expansion of the layer in that region. The study of the distribution with latitude of total ionization below the F2-layer maximum, performed in ref.[8], has shown that the latitude anomaly may be linked not only with layer's expansion at the equator, but also with the true redistribution of the ionized gas by latitude. A theoretical explanation of the anomaly as a result of ionized gas diffusion along the magnetic lines of force was considered in ref.[5, 6].

From the standpoint of anomaly nature, it is of interest to study not only the latitude distribution of f_0F2, but also the characteristics' variation with latitude of the F2-layer at various times of the day.

RESULTS OF OBSERVATIONS. We plotted on the basis of observations obtained by us the latitude dependence of f_0F2 on the magnetic inclination I, taken at the altitude of 400 km for different times of the day (Fig.1). The values of I were computed on the basis of tables of magnetic field components [9]. Despite the great scattering of the points, the averaged course of the curve $f_0F2(I)$ in daylight hours was obtained quite smooth. The averaging was taken within a 10° interval with overlapping. The root-mean-square error of average values in Fig.1 is indicated in the form of vertical strokes. The curve maximum for the northern hemisphere was observed at 1500–1700 hours LT, and for the southern hemisphere at 0900–1100 and 1900–2100 hours, The f_0F2 minimum in hours of developed anomaly closely coincides with the position of the magnetic equator at 400 km altitude. In nighttime, near 2100–2300 hours, the maxima get close to one another, and, beginning from 0100–0300 hours, the geomagnetic anomaly is feebly expressed through the morning hours. In the morning the anomaly appears at the beginning in the southern hemisphere, then in the northern, and the maximum of f_0F2 is more strongly developed in the northern hemisphere during daytime. The daily dependence $R = f_{0max}F2(I)/ f_0F2(0)$ and the distances Δ of curve's $f_0F2(I)$ maxima from the magnetic equator for the northern and southern hemisphere are plotted in Fig.2, where the solid line refers to the northern hemisphere and the dashed curve — to the southern.

For the investigation of the geomagnetic effect from the standpoint of F2-layer's behavior below electron concentration maximum we processed 230 ionograms with the aid of a BESM-2 computer and thus obtained the respective N(h)-profiles. This provided the possibility of constructing the latitude dependences of the quantities h_{max}, n, Δh, N_{max} and N for various times of the day (here h_{max} is the height of F2-layer maximum, n is the total ionization below the layer maximum, Δh is the thickness of the lower part of the F2-layer by the drop of electron concentration by e times, N_{max} is

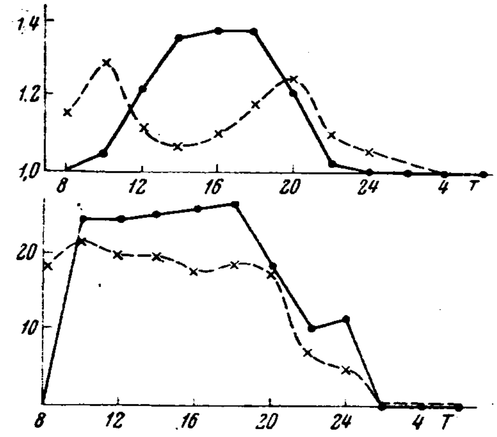

Fig.2

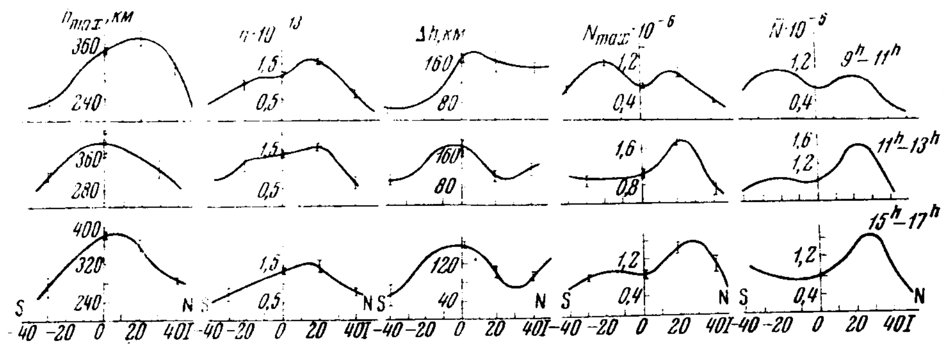

Fig.3

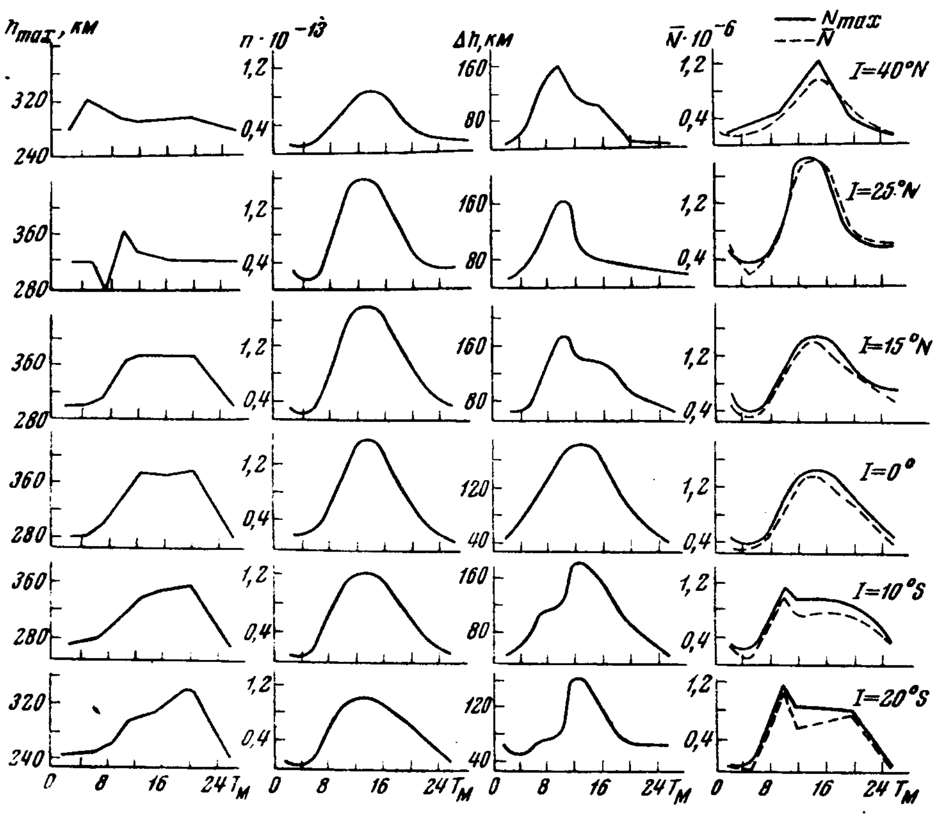

Fig.4

the maximum concentration of the F2-layer, $\bar{N} = n/\Delta h$). The latitude course of the respective quantities for certain time intervals 9–11, 11–13, 15–17 hours is represented in Fig.3. The average daily courses of the quantities n, Δh, h_{max}, N_{max} & N for values of magnetic inclination I, equal to 40, 25, 15°N, 0, 10, 20°S are brought out in Fig.4.

DISCUSSION OF THE RESULTS. The minimum of the latitude dependence $f_0F2(I)$ closely coincides with the position of the magnetic equator at 400 km height, as this follows from Fig.1. Contrary to what was noted in ref.[10], the shift of $f_0F2(I)$ maxima is not observed in daytime (Fig.2). Further, the f_0F2 maximum in daytime is greater for the summer than for the winter hemisphere. An opposite pattern is observed in the morning. It follows from the investigation of the daily dependence of the total ionization below the layer maximum (Fig.4) that the maximum of n(I) is attained nearly at all latitudes during hours close to noontime. For the northern hemisphere in daytime $n(I)/n(0) > 1$ for I $\sim$ 15°N. For the southern hemisphere n(I) is everywhere smaller than at the equator.

The curves brought out in Fig.4 for the daily course N for various values of I are close to the curves of daily dependence $N_{max}(I)$*. Because of that the variation of N_{max} with time may be interpreted with good approximation by the variation of n and Δh. Note that the daily course of $n(T_M)$ is smooth, while the thickness of the layer Δh varies rather sharply in the course of the day.

The presence of morning hour maximum of f_0F2 at I $\sim$ 20°S may be caused by the fact that the ionospheric F2-layer is significantly thinner at I $\sim$ 20°S than the layer on the equator in morning hours, though the total ionization n(20°S) is then lesser than at the equator. At the same time, in the northern hemisphere there is no maximum at I $\sim$ 15–20°N, inasmuch as here Δh is of the order of Δh on the equator, and such an increase in the thickness of the layer does not lead to maximum of N_{max} at these latitudes in morning hours. At I $\sim$ 25–40°N and I $\sim$ 20°S the layer's thickness in the latitude course of f_0F2 in hours of developed anomaly has a value $\sim$ 60–80 km. In the region of the magnetic equator the thickness of the layer is $\sim$ 160 km in this time interval (Fig. 2, 4). The decrease of N and N_{max} for I > 30°N is mainly conditioned by the decrease of total ionization n below the F2-layer maximum [$n(I = 30°N)/n(I = 0) \sim 0.6$].

At the same time the thickness of the F2-layer varies little with latitude. Inasmuch as in the interval I $\sim$ 25–40°N, in our case $\cos\chi$, also hardly changes, it may be assumed that the decrease of n is linked with the redistribution of ionization in the regions below and above the F2-layer maximum (here χ is the zenithal angle of the Sun).

The noted peculiarities in the behavior of the characteristics of the F2-layer as a function of latitude allow us to assume that for values of pre-equatorial maxima of f_0F2, the latitude distribution of total ionization n below the F2-layer maximum is as important as the altitude Δh of ionized gas brought up here.

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* The case that $\bar{N} \sim N_{max}$ is likely because by definition Δh is the thickness where N_{max} drops by e times and not to zero; the excess of $\bar{N}$ may in some cases be due to errors at averaging (Fig.4).

The presence of a maximum of total ionization $\underline{n}$ below the F2-layer maximum at I $\sim$ 15°N may be caused by ionized gas diffusion from the equatorial region and along the magnetic lines of force. No similar total ionization maximum was observed in the southern hemisphere. This may have been linked with the fact that the observations in the southern hemisphere took place in winter time, and, at the same time, the diffusion effect may then be concealed on account of $\underline{n}$ decrease in the winter time during years close to solar activity minimum. In ref.[8], where the material analyzed is obtained from measurements at numerous stations, the maximum value of $\underline{n}$ is also reached at I $\sim$ $\sim$ 15°. As already noted above, it follows also from theoretical computations performed in ref.[6] that the effect of diffusion must have the optimum expression at I $\sim$ 15°. At the same time, the presence of f_0F2 maximum at I $\sim$ 25°N and I $\sim$ 20°S is apparently not so much connected with diffusion from the equatorial region of ionized gas as with the distribution by latitude of energetic photoelectrons, formed by ultraviolet radiation of the Sun and and the temperature and reduced height of ionosphere's ionized gas (in our case it is $\sim \Delta h$). At the present time a sufficiently full theoretical consideration of the question of Earth's magnetic field influence on the distribution by latitude of energetic photoelectrons is unavailable. The preliminary calculations of [7] have led to the conclusion that the latitude distribution of energetic photoelectrons in the F2-layer may have a maximum concentration at a magnetic latitude close to the location of the maximum of electron concentration N_e and, consequently be the cause of geomagnetic anomaly.

We did not succeed in establishing any kind of relationship between the geomagnetic anomaly and the vertical drift in the F2-layer of the equatorial region (by altitude increase of the lower boundary and F2-layer height).

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